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HELIOTHIS SPP. AND THEIR PARASITES AND DISEASES ON CROPS IN THE PEE DEE REGION OF SOUTH CAROLINA, 1971-73

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HELIOTHIS SPP. AND THEIR PARASITES AND DISEASES ON CROPS IN THE PEE DEE REGION OF SOUTH CAROLINA, 1971-73

By S. H. Roach[1]

ABSTRACT

A 3-year study (1971–73) was conducted in the Pee Dee (northeastern) region of South Carolina to survey seasonal populations of *Heliothis* spp. on cultivated crops and to determine and evaluate the incidence and importance of parasites and diseases of these insect species. Records were kept of seasonal crop infestations, occurrence of parasites and diseases, and the incidence of diapause in collected larvae. The preferred early-season host for the bollworm, *Heliothis zea* Boddie, was corn, while the budworm, *H. virescens* (F.), was most prevalent on tobacco. During middle to late season, budworms predominated on cotton, while bollworms were most numerous on soybeans. Parasitism was generally by Hymenoptera, with *Cardiochiles nigricepes* (Vier.) often infesting a high percentage of budworms. *Campoletis* spp. were numerous in early season, attacking both bollworms and budworms. The entomogenous fungus *Nomuraea rileyi* (former *Spicaria*) was widespread during middle to late season and greatly limited larval populations on all hosts. Diapausing pupae of both species developed on cotton, soybeans, and numerous other fall hosts.

INTRODUCTION

Most of the major cultivated crops in the Pee ee region of South Carolina are attacked by her or both of two *Heliothis* spp.—the cotton llworm, *H. zea* Boddie, and the tobacco budrm, *H. virescens* (F.). The proportion of each ecies attacking each crop in any year varies nsiderably throughout the range of these in-cts (*2, 7, 9*).[2] Generally, the types of cultivated d wild hosts in an area determine which spes is most prevalent on a given crop. Thus, in area where numerous hosts are present, each ecies will predominate on one or more preferl hosts, such as the bollworm on corn and the dworm on tobacco. However, in some regions, such as the Presidio area of Texas, both species are confined to cotton, alfalfa, and a small acreage of other cultivated crops (*4*).

This study was conducted to survey seasonal larval populations of two *Heliothis* spp., *H. zea* and *H. virescens*, on major cultivated crops and to determine and evaluate the incidence and importance of parasites and entomogenous diseases affecting these insect species in the Pee Dee region.

METHODS

INSECT IDENTIFICATION

All *Heliothis* larvae collected during this study were placed on wheat-germ-based rearing media in 1-ounce medicine cups and were then brought into the laboratory and held under natural day lengths at 75°±3° F until they could be identified. Identification of larvae was made by the

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[2] Italic numbers in parentheses refer to items in "Liture Cited" at the end of this publication.

author, based on characters reported by Brazzel et al. (*2*), Neunzig (*5–7*), and Capps (*3*). Variations in the occurrence of the mandibular retinaculum in field-collected and laboratory-reared insects were observed. Head capsule measurements for this study were made on freshly-mounted head capsules at 20 power for all instars except the fifth, which was measured at 10 power with a calibrated ocular micrometer in a binocular microscope.

Parasites emerging from field-collected larvae were preserved in 70 percent ethyl alcohol, and selected specimens were sent to the Agricultural Research Service's Systematic Entomology Laboratory at Beltsville, Md., for identification.

THREE-YEAR SURVEY OF CULTIVATED CROPS

The first year of the study was conducted within a 10-mile radius and the last 2 years within a 40-mile radius of Florence, S.C., extending in all directions. Beginning with initial emergence of overwintered moths, each crop was sampled in a number of fields at least once each week in the immediate Florence area until the latter part of May. Thereafter, when seasonal help became available, the survey was extended to the aforementioned areas for the remainder of each season. Infestation counts in cotton, corn, tobacco, and peanuts were made by examining whole plants in three randomly selected 50-foot-row samples in 1971 and 1972, and in six 25-foot-row samples in 1973. Soybeans were sampled the same way in 1971, but in 1972 and 1973 they were sampled by shaking plants on 8 row-feet over a white cloth in six randomly selected spots in each field. Locations, dates, crops, insect species, parasites (emerging from collected larvae or pupae), disease organisms, and incidence of diapause were recorded.

RESULTS

INSECT IDENTIFICATION

Using only the presence or absence of a mandibular retinaculum as a method of identification, *Heliothis* larvae were difficult or impossible to identify until they reached the third instar. The most reliable characteristic for identification was the presence of microspines on the prothoracic and eighth abdominal (dorsal) tubercles of the budworm and their absence on the bollworm. When the microspines were used as the main identifying characteristic, second-instar larvae could usually be identified as to species with a binocular microscope at 20 power, but both characteristics were used whenever necessary. Table 1 shows the results of a laboratory study on the presence of identifying characteristics in each instar of the budworm. No first- or second-instar larvae had a distinguishable retinaculum, while spines of the tubercles were minute and sometimes difficult to distinguish if the larvae were fat and extended. Identification of first-instar larvae was not positive, but as stated previously, second-instar larvae could usually be identified. Once the third instar was reached, identification was relatively easy except for variations in the retinacula, which ranged from absent to fully formed. The

TABLE 1.—*Number of, and head-capsule measurements for, laboratory-reared* H. virescens *larvae having zero, one, or two retinacula on mandibles, 1971*

Instar	Total No. larvae	Head capsule range (mm)	No. larvae[1] 0	1	2
1	40	0.26–0.31	40	0	0
2	20	0.43–0.52	20	0	0
3	54	0.68–0.95	12	5	[2]37
4	41	1.42–1.64	0	0	61
5,[3]6	37	2.35–2.61	[4]4	0	33

[1] Zero, 1, and 2 indicate number of retinacula.

[2] Majority appeared as slight bumps or ridge-like thickenings of mandible.

[3] The occurrence of a 6th instar was not obvious.

[4] Appeared to have been broken off, as scars were on mandibles.

fourth, fifth, and sixth instars (the latter two instars were not differentiated since head capsule measurements often overlap) were easily identified by the spines and presence of a retinaculum, although one or both retinacula were occasionally missing. They were possibly broken off during feeding (*7*).

The variation in numbers of retinacula in field-collected budworms is shown in table 2. Only third-instar (or older) larvae were examined. Significant numbers of budworms were taken only from tobacco and cotton, and most of the variations generally occurred in fifth-and sixth-instar larvae from mature plants in late season,

TABLE 2.—*Number of late-instar, field-collected H. virescens larvae having zero, one, or two retinacula on mandibles, 1971*

Month	Crop	Instar	Total No. larvae	No. larvae[1]		
				0	1	2
May	Tobacco	3, 4	13	2	0	0
Do	do	5, 6	13	8	0	3
June	do	3, 4	140	2	0	11
Do	do	5, 6	140	27	0	100
Do	Cotton	3, 4	5	0	0	0
Do	do	5, 6	5	3	0	2
July	Tobacco	3, 4	177	14	0	28
Do	do	5, 6	177	49	2	84
Do	Cotton	3, 4	5	1	0	1
Do	do	5, 6	5	3	0	0
August	Tobacco	3, 4	399	20	0	31
Do	do	5, 6	399	192	52	104
Do	Cotton	3, 4	43	1	0	4
Do	do	5, 6	43	16	3	19
September	do	3, 4	37	4	0	8
Do	do	5, 6	37	3	1	21

[1] Zero, 1, and 2 indicate number of retinacula.

although many larvae collected throughout the season had no retinacula.

Parasites recovered from collected larvae usually emerged as adults and were easily identified, but occasionally some, particularly *Cardiochiles nigricepes* (Vier.), died before spinning a pupal cocoon. When parasites did not emerge from the host larvae, they were not identified. A list of all the parasitic species collected from field-collected *Heliothis* larvae during the 3-year study is given in the appendix. The majority of parasites were hymenopterous, with only three species being widespread and important in limiting host populations. *Cardiochiles nigricepes* was the prevalent parasite of the budworm, and it occurred throughout the area in larvae collected from almost every host plant. *Campoletis sonorensis* (Cam.) and *Campoletis flavicincta* (Ash.) parasitized both the budworm and bollworm in most areas. Unfortunately, the two species were not differentiated until after most collections were completed, so no data were available on their relative distribution. *Campoletis* spp. were usually very prevalent during early and late season and were the only major hymenopterous parasites attacking the bollworm.

Dipterous parasites were not common in the larval *Heliothis* collections. In general, fall collections were more heavily parasitized by Diptera, but parasitism never exceeded 5 percent of the total. The most common dipterous parasite was the tachinid *Lespesia aletiae* (Riley).

Egg parasites of *Heliothis* were not common in 1973. Only one species of *Trichogramma* (probably *minutum*) was found in eggs from major host plants of *Heliothis*. One *Trichogramma* sp. emerged from 168 eggs collected from corn and 6 emerged from 455 eggs collected from cotton, but no parasites emerged from 720 eggs taken from tobacco. Of interest was the high *Heliothis* egg hatch; most of the eggs (average of 98.3 percent) hatched regardless of the collection date, so females did not lay infertile eggs in the field as often happens in laboratory cultures.

In 1971, two Pyralidae (Lepidoptera) emerged from a budworm pupa and a late-instar budworm larva collected from tobacco. It is unclear whether they were actually parasitic or were predaceous and possibly attached to the host larvae when they were collected. In any case, they were identified as Phycitinae (near *Cadra* or *Ribua*), and members of this family have been reported as predaceous on larvae in their own order (*1*).

Another parasitic wasp, *Netelia* spp., was reported by Neunzig (*7*) as parasitizing the bollworm in coastal North Carolina, but it was not collected from the bollworm during this study (although it was quite common and was collected from one or more cutworm larvae).

1971 SURVEY

Unfortunately, the early-season infestation records of *Heliothis* spp. on tobacco and corn were lost. These crops are the primary early-season hosts for the two species—budworms on tobacco and bollworms on corn. Thus, a comparison of seasonal infestation levels and ratios of the two species for these crops was not possible, but larval numbers and parasitism rates were retained. The numbers of the two *Heliothis* spp. and associated parasites on tobacco are given in table 3. Bollworms were fairly common on tobacco during the early season, but the number declined rapidly by late June. Tobacco is harvested in July and early August in this region, and the plants are usually destroyed by mid-August. Where tobacco stalks were left standing, new growth appeared and budworms continued

TABLE 3.—*Number of* Heliothis *larvae on tobacco and their parasites and pupation, 1971*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized[2]			No. larvae pupated[3]	
			Cardiochiles[4]	*Campoletis*	Other[5]	*H. zea*	*H. virescens*
May 21–28	6	13	7	2	0	1	0
May 29–June 4	0	0	0	0	0	0	0
June 5–11	8	16	9	2	1 PR	4	0
June 12–18	6	53	27	3	1 PR	1	0
June 19–25	7	43	18	4	3 MIC	0	2
June 26–July 2	2	71	16	16	0	2	9
July 3–9	0	57	35	5	1 MIC	0	5
July 10–16	1	68	19	2	0	0	27
July 17–23	4	50	19	15	0	0	8
July 24–30	0	59	12	9	0	0	33
July 31–Aug. 6	0	280	32	24	0	0	70
Aug. 7–13	2	163	83	2	0	0	16
Aug. 14–20	1	76	41	1	0	0	6
Aug. 21–30	2	88	28	1	0	1	20 (1)
Total	39	1,037	346	86	6	9	196 (1)

[1] Percent of total — *H. zea*, 3.6; *H. virescens*, 96.4.

[2] Percent parasitized — 42.2.

[3] Percent pupation — *H. zea*, 23.1; *H. virescens*, 18.9. Number in parentheses indicates number diapaused.

[4] Specific parasite of *H. virescens*.

[5] PR, *Pristomerus*. MIC, *Microplitis*.

to infest plants. Two major parasites, *Cardiochiles nigricepes* (Vier.) and *Campoletis sonorensis* (Cam.), were found attacking budworms throughout the season. *Cardiochiles* parasitized the budworm exclusively at a rate of 40 to 60 percent throughout most of the season on tobacco. On cotton, *Cardiochiles* was considerably less prevalent but was the most important parasite of the budworm. Two other species were recovered from budworm larvae — *Microplitis croceipes* Cresson (Braconidae) and an ichneumonid, *Pristomerus spinator* (F.)—but not in sufficient numbers to be of importance.

The larval collections from corn (table 4) indicated almost no infestation by budworms. Bollworms were very plentiful, and one or more larvae per ear in milk-stage corn was common. In general, the corn crop matures in July and thereafter is no longer a suitable host for the bollworm. Almost no larval parasitism occurred on bollworms collected from corn. One unidentified ichneumonid cocoon was formed by a parasite from a bollworm collected June 11. Several egg collections made from corn also gave negative results, although *Trichogramma* spp. have been reported from this area (*7*), and some were later collected in this study.

Larval collections from peanuts were negative except for 1 week in August when 66 bollworms and 1 budworm were found. All of these larvae were infested with a fungus identified as *Nomuraea rileyi* Farlow Charles. Thus, peanuts did not serve as a primary late-season host for *Heliothis* spp. in 1971.

Soybeans also seemed to have a short period of suitability for *Heliothis* infestation (table 5). Only bollworm larvae were collected from soybeans, but numerous budworm moths were seen in the fields. None of the *Heliothis* larvae collected from soybeans were parasitized.

In 1971, cotton was the main late-season host for both the bollworm and budworm (table 6). Budworms were more prevalent on cotton in midseason, and bollworms became slightly more prevalent in late season.

The parasite found most often in larvae collected from cotton was *Cardiochiles nigricepes*. Two *Campoletis sonorensis* (found July 28 and Aug. 13), one tachinid [*Lespesia aletiae* (Riley)], and one unidentified ichneumonid, were also noted.

TABLE 4.—*Number of* Heliothis *larvae on corn and their parasites and pupation, 1971*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized[2]	No. larvae pupated[3]	
				H. zea	*H. virescens*
May 21–28	1	0	0	1	0
May 29–June 4	16	0	0	15	0
June 5–11	11	0	1 ICH	8	0
June 12–18	17	0	0	14	0
June 19–25	7	0	0	5	0
June 26–July 2	103	0	0	92	0
July 3–9	35	0	0	32	0
July 10–16	27	0	0	23	0
July 17–23	36	0	0	32	0
July 24–30	18	0	0	13	0
July 31–Aug. 6	27	0	0	25	0
Aug. 7–13	56	0	(4)	32	0
Aug. 14–20	33	1	0	12 (1)	0
Total	387	1	2	304 (1)	0

[1] Percent of total—*H. zea*, 99.7; *H. virescens*, 0.3.

[2] Percent parasitized—0.5. ICH, ichneumonid.

[3] Percent pupation—*H. zea*, 78.6; *H. virescens*, 0. Number in parentheses indicates number diapaused.

[4] Unidentified species of mites, probably feeding on diet.

TABLE 5.—*Number of* Heliothis *larvae on soybeans and their diseases and pupation, 1971*

Larval collection date	*H. zea*	*H. virescens*	No. larvae diseased[1]	No. larvae pupated[2]	
				H. zea	*H. virescens*
Aug. 14–20	28	0	12	11	0
Aug. 21–27	24	0	14	4	0
Aug. 28–Sept. 3	5	0	3	0	0
Sept. 4–10	9	0	6	3	0
Sept. 11–17	7	0	6	0	0
Sept. 18–24	1	0	0	1	0
Total	74	0	41	19	0

[1] *Nomuraea* fungus. Percent diseased—55.4.

[2] Percent pupation—*H. zea*, 25.7.

The hyphomycetous fungus *N. rileyi* became very prevalent during August and September (table 7). This period was warm and humid with slightly above-normal rainfall. Although cotton was the only late-season crop from which a substantial number of budworms were collected, they were as susceptible to the fungus as the bollworms. Undoubtedly, this epizootic was at least partially responsible for the limited development of a late-season infestation on minor host crops such as peanuts and soybeans.

Field infestation levels (fig. 1) reflected the same pattern as the larval collections given in tables 3–7. Both soybeans and peanuts had a short period of attractiveness to the moths for egg deposition. The period of peak infestation (through August) occurred when these two crops were blooming and setting fruit. Thus, when the soybeans became mature, they probably became too hard for the first-instar *Heliothis* larvae to feed on. Similarly, when blooming stopped, the peanuts had only leaves and stems for feeding sites.

TABLE 6.—*Number of* Heliothis *larvae on cotton and their parasites, diseases, and pupation, 1971*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased[2]	No. larvae pupated[3]	
				H. zea	*H. virescens*
June 12–18	1	0	1 TAC	0	0
June 19–25	0	0	0	0	0
June 26–July 2	0	0	0	0	0
July 3–9	0	4	2 CAR, 1 N	0	1
July 10–16	0	1	1 CAR	0	0
July 17–23	2	0	0	2	0
July 24–30	2	16	3 CAR, 1 CAM	1 (1)	11 (1)
July 31–Aug. 6	8	54	4 CAR	6 (2)	43
Aug. 7–13	37	107	9 CAR, 1 CAM, 2 N	27 (2)	80 (1)
Aug. 14–20	3	18	0	2	16 (1)
Aug. 21–27	0	0	0	0	0
Aug. 28–Sept. 3	0	0	0	0	0
Sept. 4–10	21	15	2 CAR, 9 N	8 (1)	2 (2)
Sept. 11–17	7	11	1 CAR, 8 N	0	3 (2)
Sept. 18–24	35	17	34 N	9 (1)	3 (1)
Sept. 25–Oct. 1	14	1	5 N	3 (1)	0
Total	130	244	84	58 (8)	159 (8)

[1] Percent of total—*H. zea*, 34.8; *H. virescens*, 65.2.

[2] Percent parasitized—6.7. Percent diseased—15.8. TAC, tachinid. CAR, *Cardiochiles*. CAM, *Campoletis*. N, *Nomuraea*.

[3] Percent pupation—*H. zea*, 44.6; *H. virescens*, 65.2. Numbers in parentheses indicate number diapaused.

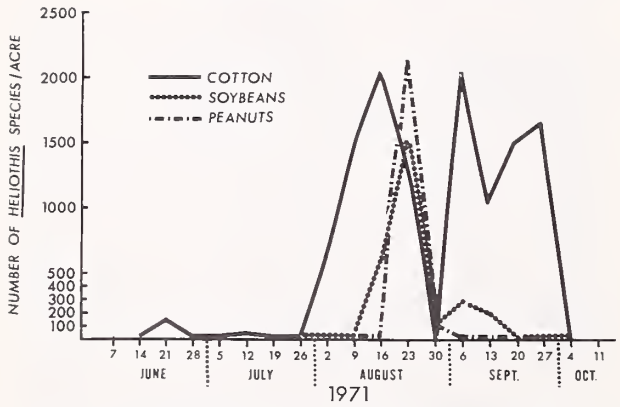

FIGURE 1.—*Heliothis* spp. larval infestations in cotton, soybeans, and peanuts at Florence, 1971.

Cotton was the only crop sampled that continued to provide feeding and oviposition sites through late season (September–October).

1972 SURVEY

Populations of *Heliothis* larvae were not measurable in cultivated crops until middle to late May. The only crop infested early in the season was tobacco, which supported low bollworm and high budworm populations from mid-May to the end of the growing season in late July. This situation occurred in all areas sampled (table 8) and represented at least two full generations of budworms. Bollworms were present in larger numbers only during the early season, particularly on plants in tobacco beds before and during transplanting. Tobacco beds left growing after transplanting supported substantial numbers of larvae of both species until the beds were destroyed.

Tobacco and wild host plants were the major sources of early-season buildup of budworm populations, which later affected cotton and other crops. The bollworm was not prevalent enough on tobacco to build up substantial populations; therefore, whorl-stage corn and wild host plants must have served as primary early-season sources of moths which later oviposited in corn.

Parasitism of *Heliothis* spp. larvae was very heavy in tobacco, and three species, *Cardiochiles nigricepes*, *Campoletis sonorensis*, and *Campoletis flavicincta*, constituted most of the parasites recovered (table 8). These species appeared to be of equal importance in the Florence area, but

TABLE 7.—*Number of* Heliothis *larvae on various crops and their infection by* Nomuraea rileyi *fungus, 1971*

Larval collection date	*H. zea*		*H. virescens*	
	No. observed	No. infected	No. observed	No. infected
	Peanuts			
Aug. 23	66	31	1	0
	Cotton			
July 8	0	0	1	1
Aug. 3	2	0	17	1
9	10	0	30	1
11	12	0	55	1
19	3	0	18	1
Sept. 7	15	3	11	1
8	9	4	4	1
14	7	4	11	4
20	12	8	9	7
22	23	14	8	5
27	14	4	1	1
	Soybeans			
Aug. 18	6	2	0	0
19	22	10	0	0
25	24	13	0	0
30	3	2	0	0
31	2	1	0	0
Sept. 7	9	6	0	0
15	7	6	0	0
	Tobacco[1]			
Aug. 9	0	0	1	1
30	0	0	1	1

[1] Not important, harvested in July and early August.

over most of the Pee Dee region *Cardiochiles* populations were more prevalent. At least three other species were recovered from larvae—*Pristomerus spinator, Microplitis croceipes,* and one or more species of *Apanteles.* These parasites were fairly widespread but were limited in number and were apparently of little importance in limiting early-season *Heliothis* populations.

Late-season collections from tobacco field regrowth in the Florence area yielded considerable numbers of larvae of both the budworm and bollworm. In fact, every field sampled yielded larvae, and some of these entered diapause. Thus, tobacco fields which are left unplowed or are not plowed adequately may serve as substantial sources of overwintering *Heliothis* spp.

One budworm collected in May from tobacco entered diapause and remained in that state throughout the summer while kept at laboratory temperature. The pupa was still healthy in September and had not broken diapause. This occurrence was contrary to normal diapause in this species and may have been an oddity or an example of genetic variability.

Corn was the major host of the bollworm during midseason, but for only one to two full generations (table 9). Some light infestations were noted in whorl-stage corn during June in the Florence area, but heavy infestations did not occur until silking and ear formation in early July. Apparently, the overwintering and first-generation bollworms were few in number, since corn in most areas never became heavily infested, especially in the Florence-Marion-Dillon areas. Corn normally matures and becomes unsuitable as a host during middle to late July in this region of South Carolina. Exceptions should be noted in areas where sweet corn is grown. This crop matures earlier in the season and has heavy infestations during June. Sweet corn planted for a fall crop (which matures in August) is heavily infested and damaged by bollworms.

The budworm did not infest corn heavily and was assumed to be only an incidental feeder on corn. However, it was consistently collected from corn during the previous two seasons, and this indicated a potential adaptation of the budworm to corn as a seasonal host. No parasites were recovered from larvae collected from corn in 1972.

From July through mid-September, cotton and soybeans were primary hosts for both the budworm and bollworm. During July, low populations began in cotton and by early August had reached extremely high levels in some fields in the region (table 10). Most of these larvae were budworms, and in two areas, Florence and Marion-Dillon, bollworms never exceeded 10 to 20 percent of the total infestation. This result may have been a reflection of the small number of moths produced on corn in the same areas, or it may have indicated a preference for soybeans (table 11), which begin to bloom in early August. Only during blooming and fruit set were heavy infestations found on soybeans. Cotton, on the other hand, has a much longer fruiting period and is attractive to the insects during and after the period in which soybeans are attractive. Bud-

TABLE 8.—*Number of* Heliothis *larvae on tobacco and their parasites, diseases, and pupation, 1972*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased by[2]—			No. larvae pupated[3]	
			Cardiochiles[4]	*Campoletis*[5]	*Other*[6]	*H. zea*	*H. virescens*
			Area 1—Florence				
May 11–31[7]	21	187	40	85	2 PR, 4 AP	3	45 (1)
June 9	8	57	8	38	2 PR	0	8
16	5	49	13	15	4 PR	2	5
23	5	34	11	2	0	4	10
30	3	18	10	1	0	0	3
July 7	1	30	8	1	0	1	17
14	0	12	1	1	0	0	8
21	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
Oct. 10[8]	0	18	8	0	1 VI	4	4
17	2	43	4	12	1 N, 2 VI	1 (1)	6 (5)
31	12	22	3	2	6 N	4	4 (1)
			Area 2—Lamar, Bishopville				
June 9	3	28	9	8	2 PR	0	1
16	1	57	20	8	0	0	7
23	1	32	16	2	0	0	5
30	1	74	20	1	1 PR	0	35
July 7	0	181	41	4	1 AP	0	92
14	0	54	16	4	0	0	31
21	0	7	0	0	0	0	2
28	0	0	0	0	0	0	0
			Area 3—Kingstree, Conway				
June 9	5	45	11	9	1 MIC, 2 AP, 2 PR	0	10
16	1	6	1	2	0	0	1
23	2	48	13	1	0	1	32
30	0	94	10	3	0	0	35
July 7	0	89	3	2	0	0	33
14	0	66	3	4	0	0	55
21	0	18	2	3	0	0	10
28	0	65	23	1	0	0	26
			Area 4—Marion, Dillon				
June 9	0	4	3	1	0	0	0
16	2	5	2	2	0	0	0
23	0	2	1	0	0	0	1
30	0	18	1	4	0	0	8
July 7	1	25	3	3	0	1	6
14	0	32	7	5	0	0	18
21	0	16	3	0	0	0	12
28	0	2	2	0	0	0	0
Total, all areas	74	1,438	316	224	31	21 (1)	530 (7)

[1] Percent of total—*H. zea*, 4.9; *H. virescens*, 95.1.
[2] Percent parasitized—37.1. Percent diseased—0.7.
[3] Percent pupation—*H. zea*, 28.4; *H. virescens*, 36.9. Numbers in parentheses indicate number diapaused.
[4] Specific parasite of *H. virescens*.
[5] 2 species, *C. flavicincta* and *C. sonorensis*, parasitized both *H. zea* and *H. virescens*.
[6] PR, *Pristomerus*. AP, *Apanteles*. VI, virus. *N*, *Nomuraea*. MIC, *Microplitis*.
[7] Tobacco beds.
[8] Field stubble regrowth.

TABLE 9.—*Number of* Heliothis *larvae on corn and their diseases and pupation, 1972*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae diseased[2]	No. larvae pupated[3]	
				H. zea	*H. virescens*
	Area 1—Florence				
June 9	5	0	0	2	0
16	1	0	0	1	0
30	10	0	0	10	0
July 7	0	0	0	0	0
14	15	1	0	14	1
21	0	0	0	0	0
28	0	0	0	0	0
	Area 2—Lamar, Bishopville				
June 9	2	0	0	2	0
30	3	0	0	0	0
July 7	8	0	0	8	0
14	43	0	0	39	0
21	35	0	0	30	0
28	0	0	0	0	0
	Area 3—Kingstree, Conway				
June 30	7	1	0	6	0
July 7	16	1	0	14	1
14	42	0	0	38	0
21	79	0	2 VI, 3 FU	60	0
28	38	0	0	31	0
	Area 4—Marion, Dillon				
July 7	0	0	0	0	0
14	0	0	0	0	0
21	41	0	0	36	0
28	20	0	0	14	0
Aug. 1	0	0	0	0	0
Total, all areas	365	3	5	305	2

[1] Percent of total—*H. zea*, 99.2; *H. virescens*, 0.8.
[2] Percent diseased—1.4. VI, virus. FU, fungus (unidentified).
[3] Percent pupation—*H. zea*, 83.6; *H. virescens*, 66.7.

worms were present in soybeans in 1972 but were not nearly as prevalent as bollworms. This was different from 1971, when no budworm larvae were found in soybeans, and was probably a result of better sampling methods.

Parasites and diseases were common in larvae in both crops. *Cardiochiles* (affecting only budworms) was again most prevalent, even in cottonfields which had received periodic insecticide treatment. No parasites were recovered from bollworms collected from cotton in 1972. Two diseases, *N. rileyi* and *Heliothis* nuclear polyhedrosis virus, were present throughout the fall and affected both *Heliothis* spp. on cotton. Neither disease reached the epidemic proportion of larvae collected in 1971. In soybeans, both species were parasitized by at least two species of tachinids and by one or more species of *Apanteles*. Virus and *Nomuraea* were also more prevalent on insects in soybeans than in cotton.

Cotton and soybeans produced diapausing pupae of both bollworms and budworms. Diapause began in larvae collected in early to mid-August and continued into collections in late September. Thus, these two crops, along with tobacco stubble and wild host plants, seem to produce most of the overwintering population of

TABLE 10.—*Number of* Heliothis *larvae on cotton and their parasites, diseases, and pupation, 1972*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased[2]	No. larvae pupated[3] *H. zea*	No. larvae pupated[3] *H. virescens*
Area 1—Florence					
July 7	1	2	0	0	0
21	0	1	0	0	1
28	0	0	0	0	0
Aug. 4	0	26	3 CAR	0	20
11	1	7	1 CAR, 3 VI	0	3 (3)
18	6	36	3 CAR	6	30 (1)
25	4	14	1 CAR	4	11 (2)
Sept. 1	0	0	0	0	0
8	13	15	3 VI	12	13 (6)
15	0	0	0	0	0
22	3	35	10 N, 1 VI	2	18 (11)
25	1	5	1 N	1	4 (3)
Area 2—Lamar, Bishopville					
July 7	0	0	0	0	0
21	0	1	0	0	0
28	2	150	6 CAR	1	113
Aug. 4	4	171	16 CAR	4	127
11	10	219	11 CAR, 1 N	8 (1)	191 (1)
18	16	177	5 CAR, 2 N	16 (2)	161 (11)
25	19	53	5 CAR, 2 N	16 (3)	43 (5)
Sept. 1	2	4	1 CAR	2 (1)	2 (1)
8	2	27	2 CAR, 2 N,1 VI	2	11 (4)
15	0	3	1 N, 1 VI	0	1 (1)
22	2	5	4 N, 1 VI	1	0
Area 3—Kingstree, Conway					
July 28	0	15	1 CAR	0	7
Aug. 4	9	106	7 CAR, 1 N	4	61
11	20	47	3 CAR	18	40
18	25	54	1 CAR	17 (2)	46 (14)
25	5	12	3 CAR, 1 N	5 (2)	7 (3)
Sept. 1	10	4	1 CAR	7 (2)	2
8	25	18	2 CAR, 5 N, 1 VI	23 (2)	9 (6)
15	14	13	7 N	10 (1)	11 (7)
Area 4 —Marion, Dillon					
July 7	0	1	0	0	1
28	0	45	1 CAR	0	42
Aug. 4	0	148	1 CAR	0	137
11	6	169	2 CAR, 1 CAM	6	154
18	7	94	3 CAR	6 (1)	87 (6)
25	8	45	2 N, 1 VI	7 (1)	37 (6)
Sept. 1	1	18	0	1 (1)	13 (5)
8	0	3	[4]7 TAC	0	2 (2)
22	1	9	2 N	1 (1)	5 (2)
Total, all areas	217	1,752	81	180 (2)	1,411 (100)

[1] Percent of total—*H. zea*, 11.0; *H. virescens*, 89.0.

[2] Percent parasitized—4.1. Percent diseased—2.4. CAR, *Cardiochiles*. VI, virus. N, *Nomuraea*. CAM *Campoletis*. *TAC*, tachinid.

[3] Percent pupation—*H. zea*, 82.9; *H. virescens*, 80.5. Numbers in parentheses indicate number diapaused.

[4] All 7 in 1 *H. virescens* larva.

TABLE 11.—*Number of* Heliothis *larvae on soybeans and their parasites, diseases, and pupation, 1972*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased[2]	No. larvae pupated[3] *H. zea*	No. larvae pupated[3] *H. virescens*
			Area 1—Florence		
Aug. 18	5	3	0	5	3
25	3	10	0	3 (1)	10
Sept. 1	126	13	1 TAC, 14 N,[4] 2 AP	103 (22)	10 (6)
8	223	4	1 TAC, 67 N, 119 VI	40 (6)	1
18	0	0	0	0	0
25	0	0	0	0	0
			Area 2—Lamar, Bishopville		
Aug. 25	16	0	1 N	15 (1)	0
Sept. 1	16	1	4 N	10 (2)	1 (1)
8	35	16	11 VI, 14 N, 2 CAR	14 (2)	7 (5)
15	36	9	13 N, 2 VI	23 (4)	5 (4)
22	5	7	5 N, 2 VI	0	6 (5)
			Area 3—Kingstree, Conway		
Aug. 25	41	1	7 TAC, 4 AP, 11 N	18 (5)	1
Sept. 1	26	4	3 TAC, 3 VI, 1 CAR, 5 N	10 (4)	3 (1)
8	7	0	1 TAC, 3 N	3	0
15	2	0	2 VI	0	0
22	0	0	0	0	0
			Area 4—Marion, Dillon		
Aug. 25	37	2	1 CAM	36 (10)	2 (1)
Sept. 1	81	1	3 AP, 12 N	59 (15)	1
8	25	0	8 N, 6 VI	11 (2)	0
15	3	0	0	2	0
22	0	0	0	0	0
Total, all areas	687	71	353	352 (74)	50 (23)

[1] Percent of total—*H. zea*, 90.6; *H. virescens*, 9.4.

[2] Percent parasitized—3.4. Percent diseased—39.8. TAC, tachinid. N, *Nomuraea*. AP, *Apanteles*. VI, virus. CAR, *Cardiochiles*.

[3] Percent pupation—*H. zea*, 51.2; *H. virescens*, 70.4. Numbers in parentheses indicate number diapaused.

[4] 27 in 1 *H. zea* larva.

Heliothis in this area of South Carolina. From collections made in the Florence area, it is probable that peanuts in commercial growing areas also produce diapausing pupae. Diapausing bollworm and budworm pupae were produced from larvae collected in middle to late August in the Florence area.

The seasonal succession of host plants for *Heliothis* spp. is demonstrated in the field infestation records in table 12. No cultivated crops, except those in isolated gardens, were found in an attractive state after late September. Numerous collections from these areas indicated that okra, tomatoes, eggplants, and peppers remained infested with *Heliothis* larvae as late as November 14 (before a killing frost). Numerous larvae taken from these plants became diapausing bollworm and budworm pupae.

1973 SURVEY

As in 1972, tobacco was the primary cultivated host for budworms. Fewer bollworms were recovered from tobacco in 1973, partially because plant beds were not sampled (table 13). Of the larvae collected and identified, 0.4 percent were bollworms and of these, 57 percent pupated, but

only 17 percent of the budworms pupated. This result was largely due to parasites, since 34 percent of all budworms identified were parasitized. No diapausing pupae were produced from larval collections from tobacco in 1973.

Parasitism, as in 1972, was largely by *Cardiochiles nigricepes, Campoletis sonorensis,* and *Campoletis flavicincta.* Only 1 percent of the larvae identified were considered as diseased by *Nomuraea,* virus, or other agents.

In contrast to 1972, corn was heavily infested by bollworms in the whorl stage and was even more heavily infested in the silking and ear stages (table 14); thus, damage was considerably heavier in 1973. The elapsed time when corn was infested indicated that three or four partial generations might be produced on corn each season. Of the larvae identified, only 0.4 percent were budworms.

(Continued on page 17.)

TABLE 12.—*Number of* Heliothis *larvae per acre in crops in the Pee Dee region, 1972*

Date	Tobacco	Corn	Cotton	Soybeans	Peanuts[1]
May 31–June 8	526	87	0	0	0
June 9–15	244	44	0	0	0
June 16–22	556	44	14	0	0
June 23–29	1,336	290	0	0	0
June 30–July 6	1,875	462	94	0	0
July 7–14	1,228	1,544	46	0	0
July 15–21	534	1,340	60	0	0
July 22–28	418	1,169	1,794	0	0
July 29–Aug. 4	0	0	4,641	0	1,089
Aug. 5–14	0	0	4,042	98	0
Aug. 15–21	0	0	2,988	22	1,656
Aug. 22–28	0	0	1,539	13,923	4,356
Aug. 29–Sept. 5	0	0	[2]1,186	11,642	87
Sept. 6–11	0	0	1,133	2,902	0
Sept. 12–18	0	0	888	980	0
Sept. 19–25	0	0	300	305	0

[1] Florence area only.
[2] Defoliation started in some areas.

TABLE 13.—*Number of* Heliothis *larvae on tobacco and their parasites, diseases, and pupation, 1973*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased[2]	No. larvae pupated[3]	
				H. zea	*H. virescens*
			Area 1—Florence		
May 12–18	0	35	1 CAR, 19 CAM, 2 AP, 2 PR, 1 HY	0	5
May 19–25	2	34	2 CAR, 14 CAM, 1 PR	1	3
May 26–June 1	0	84	10 CAR, 21 CAM, 1 AP, 1 RP, 1 DI	0	15
June 2–8	1	87	14 CAR, 16 CAM	0	20
June 9–15	1	84	20 CAR, 10 CAM, 6 PR	0	11
June 16–22	0	67	12 CAR, 8 CAM, 1 DI, 1 N	0	7
June 23–29	1	150	53 CAR, 9 CAM, 1 N, 2 VI	1	14
June 30–July 6	0	56	5 CAR, 2 VI	0	15
July 7–13	0	10	0	0	6
July 14–20	0	18	2 CAR, 2 CAM	0	4
July 21–27	0	8	2 CAR	0	2
July 28–Aug. 3	0	33	1 CAR, 1 N, 2 VI	0	8
Aug. 4–14	0	43	3 CAR, 1 N	0	23

See footnotes at end of table.

TABLE 13.—*Number of* Heliothis *larvae on tobacco and their parasites, diseases, and pupation, 1973*—Continued

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased[2]	No. larvae pupated[3] *H. zea*	No. larvae pupated[3] *H. virescens*
			Area 2—Lamar, Bishopville		
June 2–8	0	82	7 CAR, 25 CAM	0	6
June 9–15	0	61	28 CAR, 8 CAM	0	4
June 16–22	0	14	2 CAR, 1 CAM	0	1
June 23–29	0	42	6 CAR, 1 CAM	0	2
June 30–July 6	0	86	15 CAR	0	8
July 7–13	0	50	14 CAR	0	21
July 14–20	1	15	1 CAR, 2 N	1	9
July 21–27	0	17	2 CAR, 1 N	0	3
July 28–Aug. 3	0	2	0	0	2
Aug. 4–14	0	1	1 CAR	0	0
			Area 3—Kingstree, Conway		
June 2–8	0	43	10 CAR, 1 CAM	0	1
June 9–15	0	48	23 CAR, 1 CAM	0	4
June 16–22	0	81	24 CAR, 5 CAM, 1 VI	0	12
June 23–29	0	73	26 CAR, 18 CAM, 1 N, 1 VI	0	26
June 30–July 6	0	33	5 CAR, 2 CAM	0	7
July 7–13	0	4	2 CAR	0	1
July 14–20	0	11	2 CAM	0	4
July 21–27	0	15	2 CAR	0	4
July 28–Aug. 3	0	2	0	0	1
Aug. 4–14	0	2	0	0	0
			Area 4—Marion, Dillon		
June 2–8	1	45	11 CAR, 4 CAM	1	6
June 9–15	0	51	15 CAR, 2 CAM, 3 VI, 1 N	0	4
June 16–22	0	43	12 CAR	0	5
June 23–29	0	84	28 CAR, 13 CAM	0	6
June 30–July 6	0	100	34 CAR, 6 CAM	0	10
July 7–13	0	30	11 CAR, 1 CAM	0	3
July 14–20	0	2	0	0	2
July 21–27	0	1	0	0	0
			Area 5—Mullins		
June 2–8	0	0	0	0	0
June 9–15	0	9	1 CAR, 2 CAM	0	0
June 16–22	0	20	11 CAR, 1 CAM, 1 VI	0	1
June 23–29	0	43	8 CAR	0	13
June 30–July 6	0	1	0	0	0
July 7–13	0	0	0	0	0
July 14–20	0	0	0	0	0
July 21–27	0	4	0	0	2
July 28–Aug. 3	0	3	1 CAR	0	2
Aug. 4–14	0	1	0	0	0
Total, all areas	7	1,828	653	4	303

[1] Percent of total—*H. zea*, 0.4; *H. virescens*, 99.6.

[2] Percent parasitized—34.0 (*H. virescens*). Percent diseased—1.0. PR, *Pristomerus*. AP, *Apanteles*. N, *Nomuraea*. HY, *Hyposoter*. VI, virus. DI, Diptera. CAR, *Cardiochiles*. CAM, *Campoletis*. *Cardiochiles* specific parasite of *H. virescens*.

[3] Percent pupation—*H. zea*, 57.0; *H. virescens*, 17.0.

TABLE 14.—*Number of* Heliothis *larvae on corn and their parasites, diseases, and pupation, 1973*

Larval collection date	*H. zea*	*H. virescens*	No. larvae parasitized or diseased[1]	No. larvae pupated[2]	
				H. zea	*H. virescens*
			Area 1—Florence, Darlington		
May 19–25	12	0	6 CAM	0	0
May 26–June 1	26	1	2 CAM	14	0
June 2–8	51	1	1 CAM, 3 TAC (Eucelatoria)	36	0
June 9–15	34	0	0	19	0
June 16–22	9	0	0	2	0
June 23–29	0	0	0	0	0
June 30–July 6	44	2	0	31	0
July 7–13	102	0	0	73	0
July 14–20	107	0	0	33	0
July 21–27	22	0	1 N	5	0
July 28–Aug. 3	21	0	0	6	0
Aug. 4–10	19	0	0	7	0
Aug. 11–24	7	0	0	2	0
			Area 2—Lamar, Bishopville		
June 2–8	9	0	2 CAM	6	0
June 9–15	58	1	0	30	0
June 16–22	16	1	1 TAC (Archytas)	11	1
June 23–29	0	0	0	0	0
June 30–July 6	0	0	0	0	0
July 7–13	47	0	0	34	0
July 14–20	95	0	1 HY	69 (1)	0
July 21–27	59	0	0	14	0
July 28–Aug. 3	28	0	1 CAM	11	0
Aug. 4–10	45	0	1 VI	15	0
Aug. 11–24	44	0	2 N	18 (1)	0
			Area 3—Kingstree, Conway		
June 2–8	13	0	0	6	0
June 9–15	58	0	0	31	0
June 16–22	20	0	0	14	0
June 23–29	0	0	0	0	0
June 30–July 6	62	0	0	37	0
July 7–13	120	1	0	90	1
July 14–20	279	0	1 VI	134	0
July 21–27	60	0	4 VI	19	0
July 28–Aug. 3	56	0	0	37 (2)	0
Aug. 4–10	52	0	1 AP	23	0
Aug. 11–24	37	0	0	12	0
			Area 4—Marion, Dillon		
June 2–8	29	0	1 N	22	0
June 9–15	30	1	2 TAC	16	0
June 16–22	4	0	0	1	0
June 23–29	0	0	0	0	0
June 30–July 6	0	0	0	0	0
July 7–13	135	1	0	86	0
July 14–20	111	0	1 VI	26	0
July 21–27	18	0	0	2	0

See footnotes at end of table.

TABLE 14.—*Number of* Heliothis *larvae on corn and their parasites, diseases, and pupation, 1973*—Continued

Larval collection date	*H. zea*	*H. virescens*	No. larvae parasitized or diseased[1]	No. larvae pupated[2] *H. zea*	*H. virescens*
			Area 4—Marion, Dillon—Continued		
July 28–Aug. 4	50	0	0	22	0
Aug. 5–10	62	0	1 VI	36 (2)	0
Aug. 11–24	44	0	0	14 (1)	0
			Area 5—Mullins		
June 9–15	28	0	2 TAC	13	0
June 16–22	5	0	0	3	0
June 23–29	0	0	0	0	0
June 30–July 6	23	0	0	14	0
July 7–13	124	0	0	75	0
July 14–20	33	0	0	7	0
July 21–27	16	0	0	3	0
July 28–Aug. 3	35	0	0	15	0
Aug. 4–10	23	0	3 MUS	9	0
Aug. 11–24	4	0	0	2	0
Total, all areas	2,386	9	37	1,205 (7)	2

[1] Percent parasitized—*H. zea*, 1.0. Percent diseased—0.5. AP, *Apanteles*. N, *Nomuraea*. HY, *Hyposoter*. VI, virus. CAM, *Campoletis*. TAC, tachinid. MUS, Muscidae (flies).

[2] Percent pupation—*H. zea*, 51.0; *H. virescens*, 22.0. Numbers in parentheses indicate number diapaused.

TABLE 15.—*Number of* Heliothis *larvae on cotton and their parasites, diseases, and pupation, 1973*

Larval collection date	*H. zea*	*H. virescens*	No. larvae parasitized or diseased[1]	No. larvae pupated[2] *H. zea*	*H. virescens*
			Area 1—Florence		
June 6–18	2	0	0	2	0
June 19–July 6	1	0	0	0	0
July 7–18	3	3	0	1	2
July 19–26	5	16	0	1	7
July 27–Aug. 1	0	15	2 CAR	0	11
Aug. 2–8	3	23	3 VI	1	16
Aug. 9–16	30	48	1 TAC, 4 N, 1 NEM, 2 VI	14	32
Aug. 17–23	13	13	5 N	4	10 (1)
Aug. 24–31	3	8	1 CAR	3	7 (3)
Sept. 1–7	8	33	1 CAR, 7 N, 2 NEM	6 (1)	16 (9)
Sept. 8–14	2	25	6 N, 1 NEM (unidentified)	0	13 (6)
Sept. 15–21	0	2	1 N	0	1 (1)
			Area 2—Lamar, Bishopville		
July 7–13	6	1	0	5	1
July 14–20	6	1	0	5	1
July 21–27	2	3	0	0	1

See footnotes at end of table.

TABLE 15.—*Number of* Heliothis *larvae on cotton and their parasites, diseases, and pupation, 1973*—Continued

Larval collection date	*H. zea*	*H. virescens*	No. larvae parasitized or diseased[1]	No. larvae pupated[2] *H. zea*	No. larvae pupated[2] *H. virescens*
			Area 2—Lamar, Bishopville—Continued		
July 28–Aug. 3	3	27	4 CAR	1	13
Aug. 4–10	27	47	3 CAR, 1 N, 1 VI	12	33 (1)
Aug. 11–17	17	51	1 CAR, 5 N	3	27 (2)
Aug. 18–24	25	77	15 N, 1 CAR, 3 VI, 2 NEM	9 (1)	44 (5)
Aug. 25–31	6	31	3 N	1	21 (1)
Sept. 1–7	11	47	10 N, 1 VI	2 (1)	26 (11)
Sept. 8–14	0	12	3 N	0	6 (4)
			Area 3—Kingstree, Conway		
July 7–13	0	0	0	0	0
July 14–20	0	8	1 CAR	0	4
July 21–27	2	6	2 VI	0	3
July 28–Aug. 3	0	13	3 CAR	0	6
Aug. 4–10	10	15	2 N	4	11
Aug. 11–17	7	6	1 N	5	6
Aug. 18–24	3	2	2 N, 1 CAR	0	0
Aug. 25–31	3	7	5 N	1	2 (1)
Sept. 1–7	0	7	2 N, 1 VI	0	4 (2)
			Area 4—Marion, Dillon		
July 7–13	0	0	0	0	0
July 14–20	0	2	0	0	1
July 21–27	0	3	0	0	0
July 28–Aug. 3	1	19	1 CAR, 1 CAM	0	12
Aug. 4–10	6	18	2 CAR, 1 N, 2 VI	1	10
Aug. 11–17	3	4	1 VI	1	3
Aug. 18–24	16	29	2 N, 1 VI	5	23 (2)
Aug. 25–31	6	5	0	3	5 (2)
Sept. 1–7	1	29	3 N	0	19 (8)
			Area 5—Mullins		
July 7–13	0	0	0	0	0
July 14–20	0	4	0	0	2
July 21–27	2	6	2 CAR	0	2
July 28–Aug. 3	3	32	2 CAR	0	20
Aug. 4–10	11	1	1 N	4	1
Aug. 11–17	9	2	1 VI	4	1
Aug. 18–24	14	1	2 VI, 2 N	5	1
Aug. 25–31	0	7	2 N	0	5 (2)
Sept. 1–7	15	6	5 N, 2 VI	8	3 (1)
Total, all areas	285	715	143	111 (3)	432 (62)

[1] Percent parasitized—*H. zea*, 0.004; *H. virescens*, 3.0. Percent diseased—11.0. N, *Nomuraea*. VI, virus. CAR, *Cardiochiles*. CAM, *Campoletis*. NEM, nematode. TAC, tachinid.

[2] Percent pupation—*H. zea*, 39.0; *H. virescens*, 60.0. Numbers in parentheses indicate number diapaused.

Some parasites were collected from larvae on corn in 1973, including *Campoletis* spp., *Hyposoter annulipes* (Cress.), and three species of Diptera. In addition, some larvae were infected with *Nomuraea* and others had symptoms of virus infection.

Diapausing pupae were produced from larvae collected from mid-July to late August, but the percentage was very low.

In contrast to the low percentage of budworms on tobacco that pupated, 51 percent of the bollworm larvae and 22 percent of the budworm larvae from corn pupated. These results were evidently due to the low level of parasitism and disease (1.5 percent combined) occurring in these larvae.

In late June and early July, cotton began fruiting and thus became attractive to ovipositing moths of both species. Both species infested cotton throughout the July–September fruiting

TABLE 16.—*Number of* Heliothis *larvae on soybeans and their parasites, diseases, and pupation, 1973*

Larval collection date	*H. zea*[1]	*H. virescens*[1]	No. larvae parasitized or diseased[2]	No. larvae pupated[3]	
				H. zea	*H. virescens*
			Area 1—Florence, Darlington		
July 21–27	3	0	0	0	0
July 28–Aug. 3	0	0	0	0	0
Aug. 4–10	0	0	0	0	0
Aug. 11–17	10	2	4 N, 1 NEM[4]	2 (1)	0
Aug. 18–24	29	4	6 N, 2 VI, 1 NEM	10	4 (1)
			Area 2—Lamar, Bishopville		
Aug. 4–10	0	0	0	0	0
Aug. 11–17	1	0	0	0	0
Aug. 18–24	57	0	30 N, 10 VI	4	0
Aug. 25–31	5	3	1 N, 5 VI	0	0
			Area 3—Kingstree, Conway		
Aug. 4–10	15	1	0	7	1
Aug. 11–17	120	2	5 AP, 23 N, 1 CAR, 1 TAC, 1 VI	65 (4)	1
Aug. 18–24	248	1	5 TAC, 87 N, 6 NEM, 37 VI	63 (2)	1
Aug. 25–31	29	0	1 TAC, 6 N, 11 VI, 1 MA[5]	0	0
			Area 4—Marion, Dillon		
Aug. 4–10	4	0	0	2	0
Aug. 11–17	21	0	0	12	0
Aug. 18–24	95	9	1 TAC, 34 N, 19 VI	28 (5)	5 (1)
Aug. 25–31	10	4	3 N, 6 VI	2	2
			Area 5—Mullins		
Aug. 11–17	6	0	0	4	0
Aug. 18–24	3	0	3 VI	0	0
Total, all areas	656	26	318	203 (12)	14 (2)

[1] Percent of total—*H. zea*, 96.2; *H. virescens*, 3.8.

[2] Percent parasitized—2.9. Percent diseased—36.8. AP, *Apanteles*. NEM, nematode. N, *Nomuraea*. VI, virus. CAR, *Cardiochiles*. TAC, tachinid. MA, *Muscina assimilis*.

[3] Percent pupation—*H. zea*, 31.0; *H. virescens*, 54.0. Numbers in parentheses indicate number diapaused.

[4] Unidentified, probably feeding on diet.

[5] 8 *M. assimilis* in 1 pupa.

TABLE 17.—*Number of* Heliothis *larvae on minor crops at Florence and their parasites, diseases, and pupation, 1973*

Larval collection date	*H. zea*	*H. virescens*	No. larvae parasitized or diseased[1]	No. larvae pupated[2]	
				H. zea	*H. virescens*
Peanuts					
Aug. 4–10	16	2	1 TAC, 1 N	10	1
11–18	88	0	23 N, 1 NEM[3], 4 VI, 2 TAC	22 (1)	0
18–24	62	4	2 TAC, 21 N, 8 VI	6	2
Cabbages					
June 15	1	0	0	1	0
Green beans					
Aug. 16	7	0	1 N	2	0
Garden peas					
May 21–30	9	1	0	3	1
Okra					
Aug. 14–Sept. 17	4	1	2 N	2 (1)	1 (1)
Irish potato (leaves)					
May 29	1	0	0	1	0
Field peas					
Oct. 17	3	0	0	0	0
Banana peppers					
Oct. 9	1	0	1 N	0	0
Eggplants					
Aug. 20	2	0	0	2	0

[1] TAC, tachinid. N, *Nomuraea*. NEM, nematode. VI, virus.
[2] Numbers in parentheses indicate number diapaused.
[3] Unidentified, probably feeding on diet.

period, but budworms became dominant in August and, for the season, accounted for 71.5 percent of the *Heliothis* larvae collected and identified (table 15).

As in previous years, larvae from cotton were parasitized at a low rate (3 percent). Eleven percent of the larvae were diseased.

Thirty-nine percent of the bollworm larvae and 60 percent of the budworm larvae pupated. Several pupae of both species collected as larvae (after early August) entered diapause.

As in 1972, soybeans were infested with *Heliothis* larvae only during the period of blooming and fruit set, late July through August (table 16). Both species were present in soybeans in most areas, but approximately 99 percent of the larvae collected were bollworms.

Parasitism (mainly by Diptera) was a low 3.4 percent. The incidence of diseased larvae was 42.2 percent, which was mainly caused by the fungus *N. rileyi*.

The identification of *Heliothis* larvae collected from peanuts and other minor cultivated crops is presented in table 17. Peanuts were infested only during the blooming period in August, and

TABLE 18.—*Number of* Heliothis *larvae per acre in crops in the Pee Dee region, 1973*

Date	Tobacco	Corn	Cotton	Soybeans	Peanuts
May 14–21	[1]2,178	349	0	0	0
May 22–29	[1]2,266	653	0	0	0
May 30–June 8	1,588	637	17	0	0
June 9–15	971	864	0	0	0
June 16–22	902	455	21	0	0
June 23–29	1,405	0	0	0	0
June 30–July 6	1,022	848	12	0	0
July 7–13	412	2,933	29	0	0
July 14–20	205	2,889	60	0	0
July 21–27	245	1,198	264	114	0
July 28–Aug. 3	195	1,816	578	0	[1]0
Aug. 4–10	282	2,105	958	275	[1]580
Aug. 11–17	17	1,413	963	3,400	[1]6,003
Aug. 18–24	0	61	885	6,563	[1]3,248
Aug. 25–31	0	0	435	792	[1]0
Sept. 1–7	0	0	543	0	0
Sept. 8–14	0	0	156	0	0

[1] Florence area only.

both species were present with bollworms predominating.

Larval collections from other vegetable crops indicated that both species, especially bollworms, are adaptable to any number of plants with succulent foliage or seed structures. Since these collections were incidental, no estimates of field infestations were made, but garden peas, field peas, green snap beans, and okra could be important sources of moths and diapausing pupae.

Crop infestation records for 1973 (table 18) indicated a higher early season population of budworms on tobacco than in 1972; however, the midseason population was lower. More bollworms were found in immature and mature corn than in 1972. Populations of both species on cotton, which became attractive after tobacco and corn were mature, were quite low throughout the season in all areas. Infestations on soybeans occurred in the bloom stage and were less severe than in 1972. Peanuts showed a slight increase in larval infestations over 1972.

SUMMARY

Continuous full-season sampling of cultivated crops for bollworms and budworm larvae was used to determine species distribution, infestation levels, and the incidence of parasites and diseases affecting these insects.

The results indicated that tobacco and corn serve as major early-season hosts for budworms and bollworms, respectively, although wild-host plants produce a major portion of the F_1 generation moths (*8*).

During midsummer, both species oviposited in cotton and soybeans to produce third, fourth, and fifth generation moths. Many of the pupae produced from larvae collected in August and September entered diapause. The predominant species infesting cotton was the budworm, and the bollworm was more prevalent in soybeans.

Parasitism in budworms throughout the study on all crops was heaviest by *Cardiochiles nigricepes* and *Campoletis sonorensis*. The bollworm was never heavily parasitized on any crop, but *C. sonorensis* was the most common parasite of this species.

Two major diseases, *Nomuraea rileyi* and *Heliothis* nuclear polyhedrosis virus, infested larvae collected from all crops. These diseases were especially heavy in late season and definitely aided in limiting crop infestations and in preventing large overwintering populations.

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APPENDIX.—SPECIES OF INSECT PARASITES FOUND ON *HELIOTHIS* SPP. IN THE PEE DEE REGION, 1971-73

Parasite	Species	Crop
Diptera:		
Tachinidae:		
Winthemia rufopicta Bigot	*virescens*	Tobacco.
Lespesia aletia (Riley)	*zea, virescens*	Soybeans, peaunts, cotton.
Archytas marmoratus (Tns.)	do	Corn, beggarweed, soybeans.
Eucelatoria rubentis (Coq.)	*zea*	Corn.
Muscidae: *Muscina assimilis* (Fallen).	*virescens*	Cotton, soybeans.
Hymenoptera:		
Branconidae:		
Apanteles marginiventris (Cress.).	*zea, virescens*	Tobacco, soybeans.
Apanteles militaris (Walsh)	*zea*	Soybeans.
Cardiochiles nigricepes (Vier.)	*virescens*	All crops.
Microplitis croceipes (Cress.)	*zea, virescens*	Tobacco, cotton, soybeans.
Ichneumonidae:		
Campoletis sonorensis (Cam.)	do	All crops.
Campoletis flavicincta (Ash.)	do	Do.
Pristomerus spinator (F.)	do	Tobacco, cotton.
Hyposoter annulipes Cr.	*virescens*	Tobacco.
Trichogramatidae: *Trichogramma minutum* (Riley).	*zea, virescens*	Corn, cotton.
Lepidoptera: Pyralidae: Pycitinae (near *Ribua* or *Cadra*).	*virescens*	Tobacco.

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